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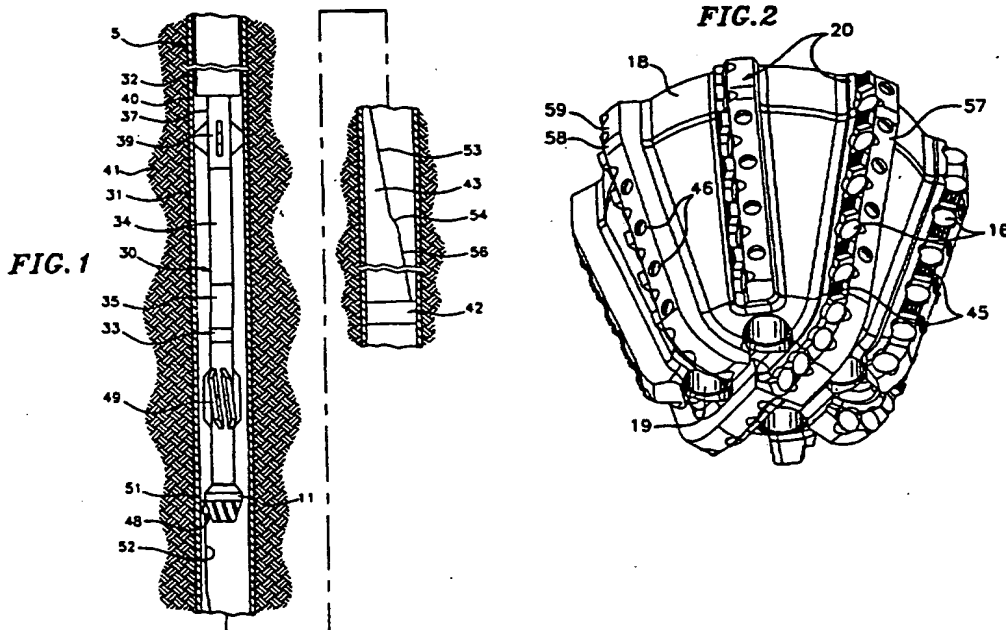
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(54) Abstract Title  
Method for milling casing and drilling formation using a dual function drill bit

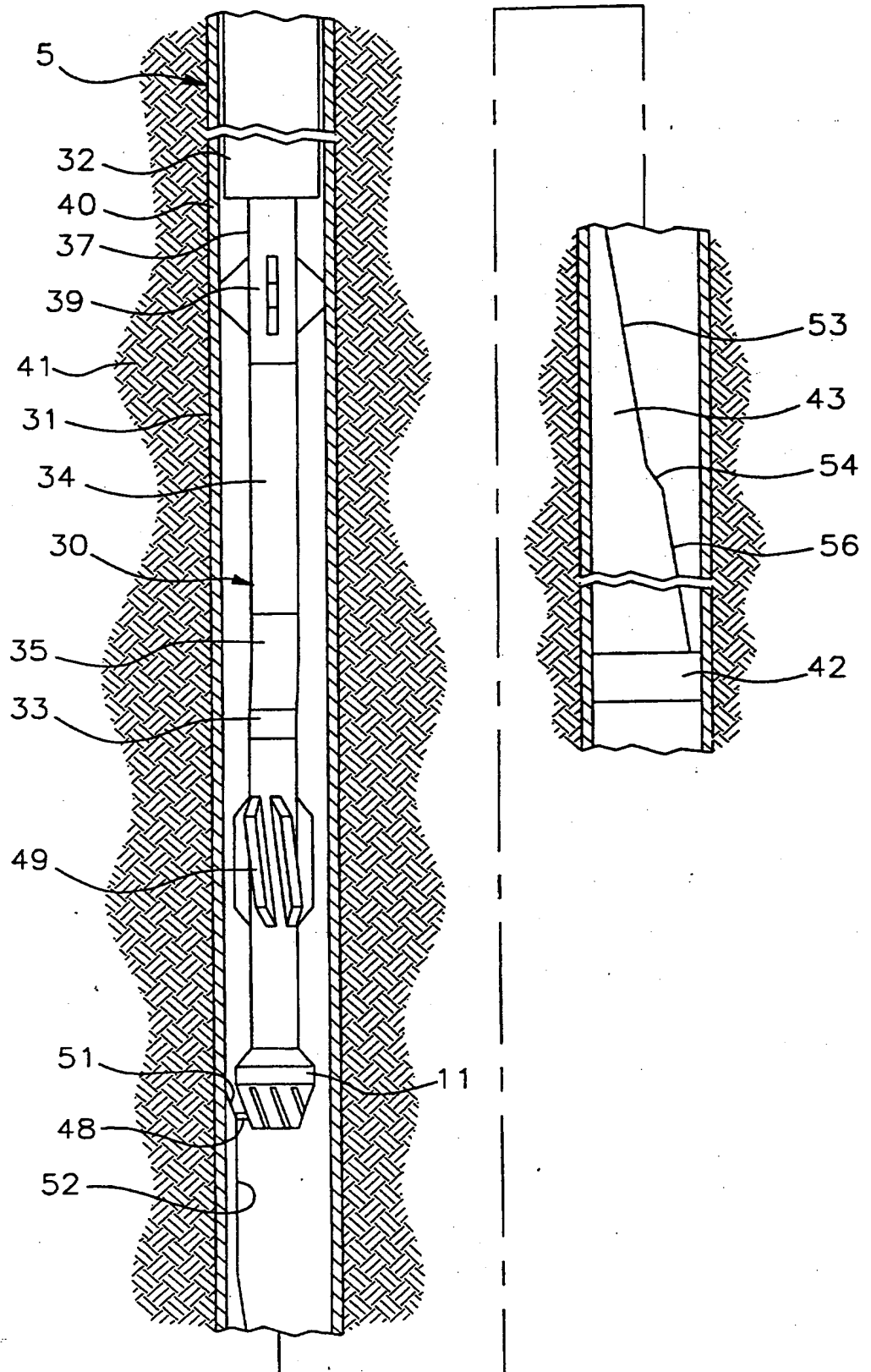
(57) A dual function drag bit 11 is used in a method for both milling well casing 40 or liner and subsequently drilling rock formation 41 without the sequential removal of a milling assembly and replacement with a drilling assembly. The method employs a cutting tool that is capable of both milling steel pipe casing in a well bore and subsequently drilling rock formation outside the well bore after passing through the casing. In one embodiment, inserts 16, figure 3) designed for embedding into the surface of a cutting tool 11 comprise at least an outer layer 22, figure 3), such as cemented tungsten carbide, capable of milling steel, and at least a second layer 23, figure 3), such as polycrystalline diamond, capable of drilling formation, the two layers being bonded together and to a carbide substrate 24, figure 3). In another embodiment, inserts 16 with a polycrystalline diamond cutting face for drilling rock formation are in parallel with cemented tungsten carbide cutters 45 for milling steel casing.



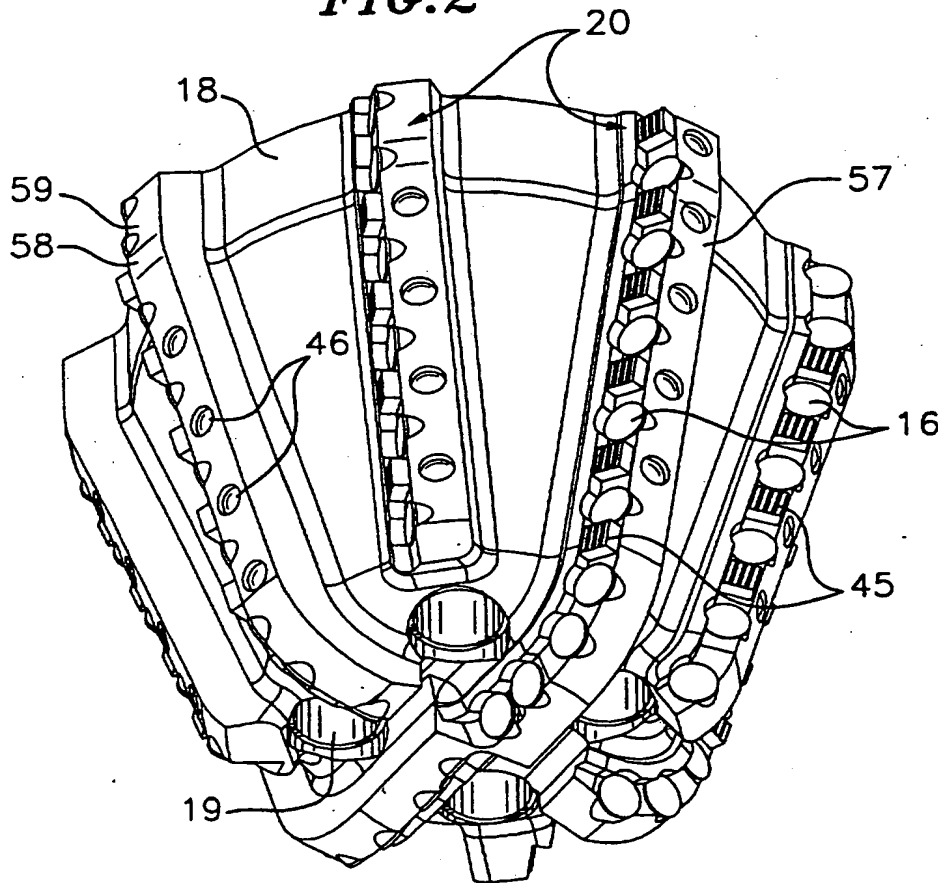
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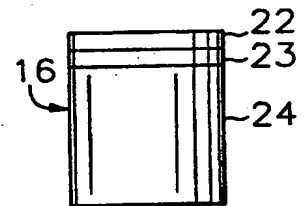
**FIG. 1**



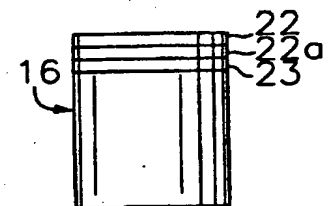
**FIG. 2**



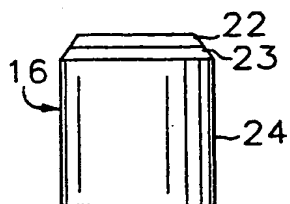
**FIG. 3**



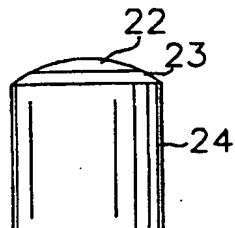
**FIG. 4**



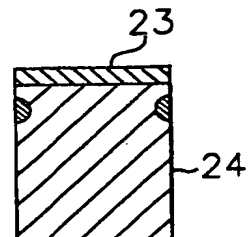
**FIG. 5**



**FIG. 6**



**FIG. 7**



METHOD FOR MILLING CASING  
AND DRILLING FORMATION

5 The present invention relates to a method for both milling well casing and/or liner and subsequently drilling rock formation without the sequential removal of a milling assembly and replacement with a drilling assembly.

10 When an existing cased oil well becomes unproductive, the well may be sidetracked in order to develop multiple production zones or redirect exploration away from the unproductive region. Generally, sidetracking involves the creation of a window in the  
15 well casing by milling the steel casing in an area either near the bottom or within a serviceable portion of the well. The milling operation is then followed by the directional drilling of rock formation through the newly formed casing window. Sidetracking enables the development of a new borehole  
20 directionally oriented toward productive hydrocarbon sites without moving the rig, platform superstructure, or other above ground hole boring equipment, and also takes advantage of a common portion of the existing casing and cementing in the original borehole.

25 Conventionally, sidetracking to develop a new borehole has required at least two separate steps, the first step requiring the milling of a window in the original well casing and the second step requiring the drilling of formation through the newly formed window to create the new borehole.

30 The first milling step is performed by either directly milling an entire elongated section of pipe casing or by milling through a particular area within the side of the casing with a mill guided by a directionally oriented ramp, or a whipstock. U.S. Patent 4,266,621 describes a milling tool for elongating a  
35 laterally directed opening window in a well casing. The

1 disclosed system requires three trips into the well, beginning  
with the creation of an initial window in the borehole casing,  
the extension of the initial window with a particular cutting  
tool, and the elongation and further extension of the window by  
5 employing an assembly with multiple mills.

By integrating a whipstock into the milling operation and  
directionally orienting the milling operation to a more confined  
area of well casing, the number of trips required to effectively  
mill a window in a well casing have been decreased. A whipstock  
10 having an acutely angled ramp is first anchored inside a well and  
properly oriented to direct a drill string in the appropriate  
direction. A second trip is required to actually begin milling  
operations. Newer methods integrate the whipstock with the  
milling assembly to provide a combination whipstock and staged  
15 sidetrack mill. The milling assembly is connected at its leading  
tool to the top portion of the whipstock by a bolt which, upon  
application of sufficient pressure, may be sheared off to free  
the milling assembly. The cutting tool employed to mill through  
the metal casing of the borehole has conventionally incorporated  
20 cutters which comprise at least one material layer, such as  
preformed or crushed tungsten carbide bonded to a carrier,  
designed to only mill pipe casing. The mills used for milling  
casing are not suitable for extensive drilling of rock formation.

Once a sufficient window has been created, the milling  
25 assembly is removed and the drilling assembly is inserted into  
the borehole and directed to the newly formed window to drill  
earthen formation. Directional drilling is achieved by a number  
of conventional methods, such as steerable systems, which, when  
used, control borehole deviation without requiring the drilling  
30 assembly to be withdrawn during operation.

A typical system may use a bottom hole motor with a bent  
housing having one fixed diameter bit stabilizer below the  
housing and one stabilizer above the housing in combination with  
a measurement-while-drilling (MWD) system. Deviation is achieved  
35 by using the motor output shaft to rotate the drill bit while

1 avoiding rotation in the drill string, thereby taking advantage  
of the alignment offset between the drill bit and motor generated  
by the bent housing. Angular variations of as high as 3 to 8°  
per 100 feet (30 meters) are possible in such a system. Proper  
5 rotation of the drill string cancels angular deviations and can  
provide for an essentially straight drill path. Deviations,  
however, continue to occur at rates up to one degree per 30  
meters as a result of variations in hole conditions, geological  
formations, and wear on the drill bit. Such variations can be  
10 corrected by steerable drilling assemblies.

Although drilling is often with a downhole motor operated  
at the end of a non-rotating drill string, one may also drill in  
a well borehole with a conventional rotating drill string.

The drilling of formation by the mill that cuts through the  
15 casing is limited in proximity to the creation of a "rat hole"  
near the existing borehole extending a distance of about five  
meters from the window through well casing. The milling assembly  
is fairly long and a rat hole is drilled into the formation to  
assure that the entire milling assembly passes through the casing  
20 and a complete window is made. A complete window is needed since  
the bits used for drilling rock formation are generally not  
considered suitable for milling casing. The rat hole is shorter  
than the bottom hole assembly used with the casing mill. Once  
the rat hole is complete, the milling cutter and bottom hole  
25 assembly is removed and followed by a third trip with a formation  
drilling assembly which then extends the borehole from the end  
of the rat hole to the next liner hanger point, the true end of  
the hole, or to an area proximate to the production zone being  
tapped.

30 Due to the high cost of oil well operations calculated both  
on a time and fixed cost basis, the current milling and drilling  
operations which require the insertion and removal of, at  
minimum, two separate tooling assemblies is inefficient and  
costly. Considerable time is lost round tripping tools in a  
35 well. A more cost effective approach to sidetracking would

1 employ a method and incorporate the requisite devices which would  
both mill a window in the original well casing and subsequently  
drill formation through the newly created window in a single  
step.

5 It would be desirable to provide a method and device which  
enables the milling of pipe casing and subsequent drilling of  
formation without requiring multiple trips.

10 The present invention employs a dual-function cutting tool  
that is capable of milling pipe casing and/or liner and  
subsequently drilling formation. An exemplary cutter embedded  
in the cutting tool comprises at least a first material layer,  
such as cemented tungsten carbide, capable of milling pipe casing  
15 and/or liner and at least a second material layer, such as  
polycrystalline diamond, capable of drilling formation, the two  
layers being bonded together and to an insert body. The  
thickness and configurations of the material layers relative to  
each other and to the carrier vary and may include beveled and  
20 twin edge constructions which vary the cutting surface and  
improve the milling and drilling operation.

The cutting tool body is attached to a bottom hole assembly  
that connects to the drill string. The cutting tool may be  
optionally attachable to a whipstock to integrate the packing,  
25 anchoring, and orienting of a whipstock with the insertion of the  
milling and drilling assembly, thereby eliminating the need for  
a separate whipstock placement trip.

The milling and drilling process is conducted by shearing  
off the connection between the whipstock and cutting tool and  
30 directing the dual function milling and drilling assembly down  
the whipstock incline toward the well casing. After a window is  
milled through the casing, directional drilling can then proceed  
by any conventional method. The same cutting tool is used for  
both milling the casing and drilling the rock formation beyond

35

1 the end of a traditional rat hole to the next liner hanger point  
or to the true end of the well.

Because the dual-function cutter eliminates the need to  
remove a milling assembly after creating a window in the pipe  
5 casing and subsequently send down a drilling assembly, the  
present invention provides a method which minimizes trips  
required to effectively sidetrack an existing borehole.

Other features and advantages of the present invention will  
become apparent from the detailed description in connection with  
10 the accompanying drawings.

Embodiments of the invention will now be described, by  
way of example, with reference to the accompanying diagrammatic  
drawings, in which:

FIG. 1 is a view of a bottom hole assembly in a well with  
15 an anchor and deviation tool.

FIG. 2 is a perspective view of an exemplary cutting tool  
for use in the present invention.

FIG. 3 is a side view of an exemplary cutter for use in the  
present invention.

20 FIG. 4 is a side view of a second embodiment of exemplary  
cutter.

FIG. 5 is a side view of a beveled cutter.

FIG. 6 is a side view of a cutter with a rounded profile for  
use in the present invention.

25 FIG. 7 is a longitudinal cross section of another embodiment  
of cutter.

Referring now to the drawings, and more specifically to FIG.  
30 1, the present invention comprises a method for both milling well  
casing and/or liner and subsequently drilling rock formation  
without the sequential removal of a milling assembly and  
replacement with a drilling assembly. Casing refers to steel  
pipe placed in well bore from approximately the ground surface.  
35 Liner refers to steel pipe placed in well bore and suspended from



1 some level (referred to as a liner hanger point) below the ground  
surface. Typically, either casing or liner is cemented in the  
well bore with a cement grout. Since both are steel pipe and it  
makes no difference for practice of this invention where the pipe  
5 is suspended, the pipe is referred to herein simply as casing.

A preferred embodiment of an apparatus capable of practicing  
the method of the present invention is shown in FIG. 1. A bottom  
hole assembly 30 with a cutting tool 11 which has the capability  
of both milling well pipe casing 40 and drilling earthen  
10 formation 41 includes a series of tools 32-39 between the cutting  
tool 11 and the drill pipe 31, described in greater detail  
hereinafter.

Unlike conventional cutting tools, the cutting tool 11  
employed in the present invention is multi functional in that it  
15 is designed to both mill pipe casing 40 and subsequently drill  
earthen formation 41. While the present invention is not limited  
to any particular design for a multi functional cutting tool  
capable of sequentially milling pipe casing and drilling  
formation, an exemplary embodiment of the cutting tool 11 is  
20 provided in FIG. 2.

In the embodiment shown in FIG. 2, the cutting tool 11, of  
a form commonly referred to as a drag bit, comprises a body 18  
with a threaded shank at the top (hidden in this view) for  
connection to a bottom hole assembly 30. The body 18 may be  
25 formed from steel or a tungsten carbide matrix infiltrated with  
a binder alloy or any other material used in the art. Extending  
outwardly from the base of the cutting tool body 18 are a series  
of arched projections or blades 20 which comprise the cutting  
tool surface and into which are embedded inserts or cutters 16.  
30 Within the cutting tool body 18 are one or more passages ending  
in openings 19 through which drilling fluid may be delivered to  
cool the cutting tool surface and remove accumulated debris.

In the illustrated embodiment, the inserts 16 comprise 13  
mm diameter cylindrical bodies of cemented tungsten carbide with  
35 a layer of polycrystalline diamond (PCD) on an end face. Each

1 insert is press fitted into a hole in the respective blade. The  
exposed faces of the inserts are cutting surfaces of the drag  
bit. The PCD layers on the inserts may be the only cutting  
elements employed in a bit, or as in the illustrated embodiment,  
5 additional milling cutters may also be employed.

A cemented tungsten carbide rectangular or oval cutter 45  
is brazed to the face of each blade at a location intermediate  
between at least some of the PCD inserts. An exemplary cutter  
is a steel cutting grade of cemented tungsten carbide about 9.5  
10 mm square and about 4.75 mm thick. Typically the cutting face  
plane of a carbide cutter leads (in the direction of rotation of  
the bit) the cutting face plane of the adjacent PCD inserts by  
about four to five millimeters. In effect, the carbide cutters  
are in parallel with the PCD layers on the inserts rather than  
15 being in series with the PCD as in the embodiment illustrated in  
Fig. 3.

As explained in greater detail hereinafter, when the bit is  
used in an oil well or the like, the carbide cutters first mill  
a window through steel casing in the well. After the window is  
20 cut, the bit operates in the surrounding rock formation. The  
carbide cutters are not as durable for cutting rock formation and  
are eroded away, leaving the PCD faces on the cylindrical inserts  
to cut rock formation as the bit is used for further drilling of  
the well. The milling cutters mounted between the PCD inserts  
25 may have different rake angles from the PCD inserts. Thus, for  
example, the carbide cutters may have a rake angle optimum for  
cutting steel and producing chips that can be readily pumped from  
the well, whereas the PCD inserts are placed with a rake angle  
better suited for drilling rock formation.

30 Cemented tungsten carbide buttons 46, which may have a layer  
of PCD on the exposed face, are inserted into the outer faces of  
the blades for wear protection of the blades as they rub against  
steel casing and rock formation. The wear buttons help maintain  
gage of the cutting tool and borehole.

1 As an alternative to providing separate pieces of cemented  
tungsten carbide on the face of the blades for cutting steel,  
carbide can be provided on the face of some or all of the PCD  
inserts. Such a layer of carbide can be used for milling steel  
5 casing, and after the bit enters rock formation, the carbide is  
eroded away leaving the PCD layer exposed for drilling rock  
formation.

As shown in FIG. 3, such an insert 16 comprises material  
layers 22, 23 which are bonded onto a carrier substrate 24 and  
10 then secured into the cutting surface of the cutting tool. As  
stated previously, the material layers have conventionally been  
designed to be mono-functional. The present invention uses a  
first material layer 22 which is capable of milling pipe casing,  
such as 9 5/8 inch steel casing, bonded to a second material  
15 layer 23 which is capable of drilling earthen formation. The  
type of metal used in the pipe casing and the type of geological  
formation being drilled determine the materials to constitute the  
first or outer layer 22 and second material layer 23.

Materials such as polycrystalline diamond, polycrystalline  
20 cubic boron nitride (PCBN), natural diamond, titanium nitride,  
tungsten carbide or tungsten carbide cemented with cobalt can be  
used in either the first layer 22 or second material layer 23,  
as suitable for the intended functions of milling steel casing  
or drilling rock formation, respectively. It is within the  
25 knowledge of one skilled in the art to choose the proper  
combination of material layers based upon the type of casing and  
geological formations being encountered.

If milling a 9-5/8 inch steel casing, a preferred embodiment  
of the present invention employs a first material layer 22 made  
30 of cemented tungsten carbide bonded to a second material layer  
23 made of polycrystalline diamond. PCBN can be used in the  
first material layer 22 but, relative to a milling grade of  
tungsten carbide, it does not mill steel as effectively. Both  
tungsten carbide and PCBN are preferred materials for the first

1 material layer 22 over PCD because, unlike PCD, they do not react  
with iron.

Preferably, the second layer is formed of PCD which is found  
to drill rock formations effectively. Additionally, natural  
5 diamond may be employed when certain geological formations, such  
as sandstone, are expected to be encountered. Thus, a preferred  
insert for a bit for both milling casing and drilling rock  
formation comprises a body of cemented tungsten carbide 24,  
usually of a tough grade for mounting in the bit body. A layer  
10 of PCD 23 is formed on an end face of the body and a layer of  
steel cutting grade cemented tungsten carbide 22 is formed over  
the PCD.

Such an insert is formed by placing a layer of diamond  
particles, possibly mixed with cobalt powder, adjacent to a body  
15 of cemented tungsten carbide. A layer of tungsten carbide powder  
and cobalt powder (or a cobalt foil layer and layer of carbide  
particles) is placed over the diamond layer. This assembly is  
placed in a refractory metal "can" and a pressure transmitting  
medium, and processed in a high pressure, high temperature press  
20 at a temperature and pressure where diamond is thermodynamically  
stable. This forms an integral insert with a carbide body, PCD  
layer and carbide layer.

Optionally, as shown in FIG. 4, an intermediate layer 22a  
juxtaposed between the first material layer 22 and second  
25 material layer 23 can be used for brazing a preformed layer of  
cemented tungsten carbide on a layer of PCD. Additionally, chip  
breakers (not shown) may be used to enable the breaking off of  
top chip layers to increase the effectiveness of the milling and  
drilling process. A plurality of material layers may be used in  
30 the insert 16 of the present invention without exceeding the  
scope of the invention, provided the material layers enable the  
sequential milling of pipe casing and drilling of earthen  
formation.

The placement of each material layer 22, 23 relative to each  
35 other and to the insert body 24 can take numerous configurations

1 and is dependent and determined by the expected wear profile.  
One preferred embodiment, shown in FIG. 5, employs a beveled  
structure where the first layer 22 substantially covers the  
second layer 23 and both material layers 22, 23 cover the face  
5 of the insert body. The beveled edge has an angle corresponding  
to the rake angle of the insert mounted in the bit body. This  
may improve the performance of the insert and minimize chipping.  
For directional drilling, a rounded insert profile, shown in FIG.  
6 can be used to attain sufficient side loading. Different  
10 geometries of insert may be used in the gage rows and in inner  
rows on the cutting tool.

The cutting tool 11 is used in conjunction with a bottom  
hole assembly 30 which stabilizes the cutting tool, provides the  
motive force for rotating the cutting tool, and after milling  
15 through casing, directionally controls the movement of the  
cutting tool in rock formation. While components of the bottom  
hole assembly may be varied without exceeding the scope of the  
claimed invention, the bottom hole assembly is described in  
relation to an exemplary embodiment illustrated semi-  
20 schematically in FIG. 1. It will be recognized that the relative  
lengths and diameters of the parts of the bottom hole assembly  
may be rather different from what is illustrated.

The bottom hole assembly 30 comprises drill collars 32, a  
rotatable shaft 33, a bottom-hole motor output shaft (not shown),  
25 bottom-hole motor 34, a bent housing 35, one or more stabilizers  
39 and a connector sub 37. The cutting assembly includes cutting  
tool 11 for milling casing and drilling rock formation as  
provided in practice of this invention, and a second milling tool  
49 above the cutting tool. The cutting tool 11 opens a window  
30 through the casing in a well and the second milling tool enlarges  
and cleans up the shape of the window. A third milling tool may  
also be used if desired. The second and third milling tools are  
conventional watermelon mills or window mills.

The cutting assembly connects to the bottom hole assembly  
35 30 by connecting to the rotatable shaft 33 which, in turn, is

1 connected to the output shaft (not shown) of the bottom-hole  
motor 34 through a bent housing 35. The housing of the bottom-  
hole motor connects to the sub 37. Three or more stabilizers 39  
5 are typically spaced along or above the bottom hole assembly to  
keep portions centralized in the borehole. The stabilizers  
commonly employed are cylindrical tubes treated with hard facing  
material, such as tungsten carbide, with projections or blades  
welded onto or machined integral with the cylindrical body. The  
10 drill collars 32, heavy pieces of pipe with small internal  
diameters, are fitted along the drill string to impress weight  
on the cutting tool.

The bottom hole assembly may be guided to the area of well  
casing where penetration is desired through any method currently  
used in the art. One approach is to introduce a packer 42 into  
15 the existing well 5 followed by a drill guiding tool, such as a  
whipstock 43, which deflects the bottom hole assembly toward the  
side of the well and onto the pipe casing 40. Having a ramped  
surface 44 with an inclination toward the borehole wall, the  
whipstock 43 substantially acts as a bearing surface for  
20 laterally forcing the bottom hole assembly 30, particularly the  
cutting tool 11, into the pipe casing 40. The whipstock 43 is  
preferably made of a material, such as steel, which is not easily  
worn or destroyed by the action of a cutting tool rotating  
downward along the whipstock and impacting the surface 44  
25 thereof.

Preferably, the deviation of the bottom hole assembly would  
employ an approach which minimizes the number of trips required  
for the entire milling and drilling operation. One such device  
and method is disclosed in U.S. Patents Nos. 5,154,231 and  
30 5,455,222. An anchor is hydraulically set in the well 5 and is  
connected to the lower end of a tool which connects to the  
surface of the whipstock 43. Positioning dogs are employed  
between the anchor and whipstock to position the whipstock at the  
appropriate angular position within the well.

35

1       The bottom hole assembly can be connected to the whipstock  
to both facilitate positioning and eliminate the requirement of  
separate trips for positioning the whipstock and initiating  
milling and drilling operations. The cutting tool 11 may be  
5       connected to the top portion of the whipstock by a bolt 48 which,  
upon application of sufficient pressure, is sheared off, thereby  
releasing the bottom hole assembly from its fixed position  
relative to the whipstock and permitting it to proceed down a  
path toward the pipe casing defined by the inclination of the  
10       face of the whipstock. The connection between the bit and the  
whipstock may be hollow and/or connected via a port through the  
body of the bit so that upon shearing off of the connection, the  
port is opened and serves as a fluid port during the milling and  
drilling operation.

15       The drag bit for milling casing and drilling adjacent rock  
formation after a window is cut through the casing, is preferably  
used with a whipstock having complementary surfaces, as described  
in U.S. Patent Application Serial No. 08/642,829, assigned to the  
same assignee as this application. The subject matter of the  
20       pending application is hereby incorporated by reference.

In a typical embodiment, the whipstock has a ramp surface  
with several different angles relative to the axis of the  
borehole in which it is placed. At the upper end of the  
whipstock there is a short surface 51 having an angle of about  
25       15° which is useful for starting the cutting of a window. Just  
below the starting ramp 51, there is an elongated surface 52,  
which is parallel to the axis of the hole. The length of the  
parallel surface is about the same as the distance between the  
first cutting tool 11 and the second milling tool 49. Next,  
30       going down the borehole, there is a ramp surface 52 on the  
whipstock with an angle of about 3° from the borehole axis. The  
3° surface continues until it reaches approximately the  
centerline of the borehole. At that elevation there is a short  
15° "kickoff" surface 54. Below the kickoff surface the face of  
35       the whipstock reverts to a 3° angle.

1       The cutting tool 11 used for milling casing and subsequently  
drilling rock formation, has complementary angles on the blades  
20 and inserts in the blades. At least a portion of the blades  
adjacent to the bottom end of the cutting tool or bit, extend  
5 approximately to the centerline of the bit so that inserts  
mounted adjacent to the center may mill the steel pipe and drill  
rock formation. The principal length of the tool for milling and  
drilling defines a conical surface 57 having an included half  
angle of 15° (i.e., complementary to the 15° angles at the upper  
10 end of the whipstock, and on the kickoff face). Next (going in  
the up-hole direction) there is a shorter portion 58 having an  
angle of 3° relative to the axis of the tool. Finally, near the  
upper end of the cutting tool, there is a portion 59 parallel to  
the axis and having a diameter or gage corresponding to the gage  
15 of the sidetrack hole to be formed in the rock formation.

As the assembly for milling a window in steel casing and  
drilling adjacent rock is used, the 15° portion of the cutting  
tool engages the 15° starting surface on the whipstock. This  
forces the rotating cutting tool laterally into the steel of the  
20 casing to commence milling the casing. This also brings the  
second "watermelon" mill 49 against the casing to mill an upper  
portion of a window through the casing above the whipstock. The  
relative areas of the portion of the cutting tool engaging the  
whipstock and casing, are preferably arranged so that the cutting  
25 tool primarily mills casing without greatly damaging the surfaces  
of the whipstock (whipstocks are conventionally made with  
materials that are more resistant to milling than are steel  
casings encountered in oil wells).

After the cutting tool has penetrated the casing, the tool  
30 passes to the portion 52 of the whipstock that has a surface  
parallel to the axis of the borehole. Thus, the cutting tool  
progresses downwardly, milling casing without progressing further  
into the cement and rock formation surrounding the casing. This  
continues to permit the watermelon mill to reach the level where  
35 the first cutting tool penetrated the casing. Thereafter, the



1 3° portion of the cutting tool engages the 3° ramp surface 53 on  
the whipstock, and is further forced laterally into the casing  
and surrounding cement; gradually enlarging both the length and  
width of the window through the casing. The watermelon mill  
5 follows, cleaning up the window made by the cutting tool.

As the center of the cutting tool approaches a point where  
it should be milling casing, the 15° portion of the cutting tool  
engages the kickoff surface 54. This tends to force the cutting  
tool laterally through the casing and surrounding cement at a  
10 relatively rapid rate through the portion of the milling  
operation where the center of the cutting tool is cutting the  
steel of the casing. This is a part of the milling operation  
where the rate of penetration is relatively lower and is desired  
to proceed through this part rapidly.

15 After the center of the dual function cutting tool has  
passed through the casing, the cutting tool engages the final 3°  
ramp 56 on the whipstock and proceeds to enlarge the window  
through the casing and extend further into the rock formation.  
Meanwhile, the second milling tool 49 continues to enlarge and  
20 clean up the window through the casing.

Typically, in the past, the sidetracking operation has  
continued after the initial milling tool has passed through the  
casing to produce a short rat hole in the formation adjacent to  
the original borehole, which has sufficient length to accommodate  
25 at least the second (and third if used) milling tools, and  
usually a small additional portion of the bottom hole assembly.  
The prudent driller typically makes the rat hole deep enough to  
assure that the subsequent drill bit will pass cleanly through  
the window. A typical rat hole is four or five meters deep and  
30 is not drilled deep enough to accept the entire bottom hole  
assembly.

The bottom hole assembly embodiment of FIG. 1 permits the  
exertion of directional control over the milling and drilling  
process. As discussed in RE 33,751, the offset of the cutting  
35 tool from center, created by the bend angle of the bent housing

1 35 located between the cutting tool and bottom-hole motor,  
enables the exertion of control over the angular orientation of  
the cutting tool within the formation and, therefore, the  
direction of drilling. The magnitude and vector orientation of  
5 the cutting tool are further affected by the size and location  
of stabilizers and the weight on the cutting tool. It is within  
the knowledge of one skilled in the art to properly determine the  
aforementioned variables in order to achieve a desired direction  
for drilling.

10 The operation of the present invention is unique in that it  
eliminates separate trips down the well for the purpose of  
milling pipe casing and drilling formation. The bottom hole  
assembly is inserted into the well in connection with a whipstock  
which is hydraulically anchored within the well. The connection  
15 between the bottom hole assembly and whipstock, often located  
proximate to the cutting tool in the form of a bolt 48, is  
severed upon application of sufficient force, permitting the  
bottom hole assembly to be directed toward the pipe casing by the  
bearing surfaces of the whipstock.

20 Once the milling process is complete and a sufficient window  
is formed, the dual-purpose cutting tool, directed by the bottom  
hole assembly, continues through the window and forms a rat hole  
extending from the well and into surrounding formation 41,  
defined in distance from the well at about five meters from the  
25 bottom of the window. In a conventional milling operation, the  
casing mill is run into the rat hole about five meters. A  
typical casing mill has two or three milling cutters and by  
drilling a rat hole five meters beyond the window, the driller  
is certain that the elongated window is full size completely  
30 through the steel casing and the last of the milling cutters has  
cleared the casing. The milling tool is then withdrawn from the  
well. Traditionally, this occurs before the entire bottom hole  
assembly has passed through the window in the casing. By that  
time, the whipstock has essentially no further directional  
35 influence on the direction of drilling by the cutting tool.

1 Further cutting of the rock formation outside the casing is  
usually undesirable since the conventional casing mill is  
designed specifically for cutting casing and is not particularly  
well suited for drilling formation. Certainly the milling tool  
5 would not be run into the formation more than fifteen meters  
beyond the bottom of the window, far beyond the usual depth of  
the rat hole. The casing mill wears rapidly in the rock  
formation and is not suitable for drilling to the next liner  
hanger point or true bottom of the well. At the point where a  
10 rat hole has been formed, a conventional casing mill would be  
withdrawn from the borehole and a conventional drill bit run in  
for drilling rock formation outside the casing. The conventional  
drill bit is not particularly well suited for milling casing and  
would, typically, have unacceptable wear when so used.

15 In practice of this invention, however, the same drag bit  
is used for milling through the casing and for drilling rock  
formation to the next liner hanger point, for example. This is  
typically more than fifteen meters beyond the sidetracked well  
bore, much further than a traditional rat hole. As the dual-  
20 function bit drills further into the formation the downhole motor  
and bent housing assembly are used for steering to provide  
directional control of the borehole being drilled. Alterna-  
tively, steering may be provided by way of a steerable bottom  
hole assembly on a rotating drill string.

25 In an embodiment with inserts as described and illustrated  
in Fig. 3 are employed, when the inserts 16 have had the outer  
material layer designed to mill the pipe casing worn away, the  
second material layer 23 designed to drill formation is exposed.  
The drilling of rock formation continues due to the rotary  
30 application of the combined milling and drilling tool to  
formation for a desired distance beyond the length of a  
conventional rat hole. The drilling of formation can continue  
without requiring the removal and/or replacement of the drilling  
assembly until the next liner hanger point is reached by the

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1 cutting tool or until the cutting tool reaches the true end of  
the newly sidetracked well.

5 A presently preferred embodiment of dual function insert has  
an outer layer of cemented tungsten carbide since this material  
is particularly well suited for milling steel. The second layer  
is preferably PCD since this material is particularly well suited  
for drilling a variety of rock formations. The thickness of the  
layer of carbide on the PCD layer is sufficient to assure that  
the dual function bit has milled completely through the casing.  
10 This is typically about 3/4 millimeter, but thinner layers may  
be suitable when thinner wall casing is being milled.  
Preferably, the thickness of carbide is not much more than 3/4  
millimeter since wear of the carbide from the diamond can change  
the geometry of the insert so much that the bit geometry and gage  
15 may be adversely affected.

Another embodiment has an outer layer of PCD having a  
relatively larger average crystallite size, for example about 40  
micrometers. This overlies another layer of PCD having a  
relatively smaller average crystallite size, for example, 30  
micrometers or less. A coarser grain size PCD may be suitable  
20 for milling steel at a relatively low rotational speed where the  
diamond is not overheated. The finer grain size PCD is better  
suited for drilling rock formation. The diamond grain sizes in  
the two layers may blend together without a sharp change in grain  
size.  
25

It is also found that coarse grain PCD may be used for both  
milling casing and drilling rock formation when not overloaded  
or overheated. A drag bit with PCD faced inserts, wherein the  
diamond has an average crystallite grain size of about 40 microns  
30 has been found suitable for milling casing and continuing to  
drill rock formation far beyond the traditional depth of a rat  
hole. Typical thickness of PCD on an insert is in the order of  
3/4 millimeter.

Alternatively, a bit having PCD inserts and cemented  
35 tungsten carbide cutters may be used, in which case the cutters

1 wear away in the rock formation and the PCD inserts take over the  
drilling operation.

5 In an exemplary sidetracking operation, a window may be cut  
in a 9-5/8 inch casing and about 100 meters of hole drilled with  
an 8-1/2 inch drilling bit. A 7-1/2 inch liner is then cemented  
in the sidetracked hole, and a 4-1/2 inch bit used to drill  
further into the formation. Traditionally, two bits are used for  
milling the casing and drilling the 100 meter extension. With  
10 this invention, a single dual function drag type bit with PCD  
inserts may be used for both milling a window through the casing  
and extending the hole 100 meters or more through the formation  
for placement of a liner.

15 In another embodiment, a layer of PCD may be formed on a  
carbide body. This is covered with a layer of titanium nitride  
or titanium carbonitride which is used as the material for  
milling the steel casing.

20 Still another embodiment of insert, as illustrated in FIG.  
7, has what amounts to two cutting edges. A carbide body 24 has  
a layer 23 of PCD on an end face. A layer of carbide may be  
formed or brazed over the PCD if desired, or the diamond layer  
may be used for milling the steel casing. In this embodiment  
there is also a ring or band of PCD formed in a circumferential  
groove around the cemented tungsten carbide body. As this  
embodiment of insert is used, the layer of PCD on the front face  
25 may wear and the additional band of PCD then serves as a second  
cutting edge. If desired, the edges of the insert may be beveled  
at the rake angle so that the second cutting edge is exposed at  
the beginning of drilling.

30 The inserts described and illustrated herein have each  
featured a cylindrical cemented tungsten carbide body with  
layers of material for milling casing and drilling rock formation  
on one end face. It will be apparent to those familiar with drag  
bits that other types of inserts may be employed. For example,  
one popular type of PCD insert has a disk-like carbide substrate  
35 with a layer of PCD formed on one face. This disk of carbide is

1 brazed at an angle to a carbide stud which is inserted in a hole  
in the bit body. Other geometries of inserts may also be  
employed.

5 The present invention is not specifically limited to any  
particular type of borehole and can be employed in wells  
including but not limited to wildcat, test, out-post,  
development, exploration, injection and production wells for oil,  
gas or geothermal energy. Furthermore, while the invention is  
described in connection with preferred embodiments, the present  
10 invention is not limited to those embodiments and should be  
considered to include all equivalents that may be included within  
the scope of the invention as defined by the claims.

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1     CLAIMS

1. A method of drilling a portion of a well comprising the steps of:

5       introducing a dual function tool into a well bore;  
      milling a window in well casing in the well bore with the dual function tool, including drilling a rat hole in formation adjacent to the well bore; and  
      continuing to drill formation beyond the end of the rat hole  
10     with the same dual function tool.

2. A method of drilling a portion of a well comprising the steps of:

      introducing a dual function tool into a well bore;  
15     milling a window in well casing in the well bore with the dual function tool; and  
      continuing to drill formation adjacent to the well bore with the same dual function tool until at least an entire bottom hole assembly connected to the dual function tool has passed through  
20     the window in the well casing.

3. A method of drilling a portion of a well comprising the steps of:

      placing a sidetracking whipstock in a well bore;  
25     introducing a dual function tool into the well bore;  
      milling a window in well casing adjacent to the whipstock with the dual function tool; and  
      continuing to drill formation adjacent to the well bore with the same dual function tool beyond a location where the whipstock  
30     has an influence on the direction of drilling by the dual function tool.

1           4. A method of drilling a portion of a well comprising the  
steps of:  
          introducing a dual function tool into a well bore;  
          milling a window in well casing in the well bore with the  
5   dual function tool;  
          continuing to drill formation adjacent to the well bore with  
the same dual function tool; and thereafter  
          steering the dual function tool for directional control in  
the formation being drilled.

10           5. A method of drilling a portion of a well comprising the  
steps of:  
          introducing a dual function tool into a well bore;  
          milling a window in well casing in the well bore with the  
15   dual function tool;  
          continuing to drill formation adjacent to the well bore with  
the same dual function tool more than fifteen meters beyond the  
bottom of the window through the well casing.

20           6. A method of drilling a portion of a well comprising the  
steps of:  
          introducing a dual function tool into a well bore;  
          milling a window in well casing in the well bore with the  
25   dual function tool;  
          continuing to drill formation adjacent to the well bore with  
the same dual function tool to the next liner hanger point in the  
well.

30           7. A method of drilling a portion of a well comprising the  
steps of:  
          introducing a dual function tool into a well bore;  
          milling a window in well casing in the well bore with the  
dual function tool;

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1 continuing to drill formation adjacent to the well bore with  
the same dual function tool to the true end of the well.

5 8. A dual function bit for milling casing in a well bore  
and for drilling rock formation outside the well bore comprising:

a drag bit body; and

a plurality of inserts in the drag bit body, each of the  
inserts comprising:

an insert body,

10 a layer of polycrystalline diamond material on a  
cutting face of the insert body, and

a layer of softer material over the layer of  
polycrystalline diamond, the softer material layer having  
a sufficient hardness and thickness for milling through  
15 steel casing in a well bore.

9. A dual function bit according to claim 8 wherein the  
layer of softer material is selected from the group consisting  
of polycrystalline cubic boron nitride, titanium nitride,  
20 titanium carbonitride, tungsten carbide or cemented tungsten  
carbide.

10. A dual function bit according to claim 8 wherein the  
layer of softer material comprises cemented tungsten carbide.

25 11. A dual function bit for milling casing in a well bore  
and for drilling rock formation outside the well bore comprising:

a drag bit body; and

30 a plurality of inserts in the drag bit body, each of the  
inserts comprising an insert body having a layer of  
polycrystalline diamond material on a cutting face of the insert  
body for drilling rock formation; and

a plurality of cemented tungsten carbide cutters mounted on  
the body in parallel with the inserts for milling steel casing.

1           12. A dual function bit according to claim 11 wherein each  
of the cemented tungsten carbide cutters has a cutting face  
leading the cutting faces on adjacent inserts.

5           13. A dual function bit for milling casing in a well bore  
and for drilling rock formation outside the well bore comprising:  
a drag bit body having a longitudinal axis;  
a plurality of cutting blades arrayed around the body, at  
least a portion of the cutting blades comprising:

10           a first elongated milling portion extending along a  
principal portion of the body and having relatively larger  
angle relative to the axis of the body for milling a window  
through steel casing and kicking-off in a sidetracked  
borehole, and

15           a second milling portion extending along the body and  
having a relatively smaller angle relative to the axis of  
the body for milling steel casing;

20           a plurality of inserts, each including a polycrystalline  
diamond cutting face, on each blade for drilling rock formation  
outside of a well bore; and

            a plurality of cemented tungsten carbide cutting faces on  
each blade for milling steel casing in the well bore.

25           14. A dual function bit according to claim 13 wherein at  
least a portion of the cemented tungsten carbide cutting faces  
are in parallel with adjacent inserts.

30           15. A dual function bit according to claim 14 wherein each  
of the cemented tungsten carbide cutting faces leads the cutting  
faces on adjacent inserts.

35           16. A dual function bit according to claim 13 wherein each  
of the cemented tungsten carbide cutting faces is in series with  
the polycrystalline diamond cutting faces on the inserts.



Application No: GB 9903332.6  
Claims searched: 1

Examiner: Dr. Robert Fender  
Date of search: 10 May 1999

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:  
UK Cl (Ed.Q): E1F  
Int Cl (Ed.6): E21B  
Other: Online: WPI, EPODOC

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage  | Relevant to claims |
|----------|--|--------------------|
| X        | GB 2304760 A (TIW CORPORATION)             | 1                  |
| X, E     | WO 98/13572 A1 (BAKER HUGHES INCORPORATED) | 1                  |
| A        | WO 98/34006 A1 (WEATHERFORD/LAMB)          | -                  |

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P Document published on or after the declared priority date but before the filing date of this invention.  
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